MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

EMF3066 – ANTENNA AND PROPAGATION

(TE)

07 MARCH 2019
09:00 a.m. – 11:00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 4 pages with 5 Questions only.

2. Attempt **ALL FIVE** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) Find the directivity of a short dipole (also referred to as a Hertzian dipole or infinitesimal dipole) as a function of the directional angles.

[8 marks]

(b) Find the maximum directivity and gain of the short dipole and express it in decibels. Assume that the antenna element is lossless with an efficiency k equal to 1.

[2 marks]

(c) An antenna radiates only into the upper hemisphere and its normalized radiation intensity is given by $U(\theta,\phi)=\cos^2\theta$. Calculate the total radiated power of the antenna.

[5 marks]

(d) Draw the equivalent circuit of a receiving Hertzian dipole and derive the expression of its effective aperture as a function of directivity D and wavelength λ.

[5 marks]

Question 2

(a) An array is constructed with two half-wave dipoles spaced half-wavelength apart $(d = \lambda/2)$. The dipoles are arranged along the Z-axis, with the dipole oriented parallel to the X-axis, as shown in Figure Q2(a) below. The dipoles are fed with equal power and have a progressive phase shift (α) of 60° between elements.

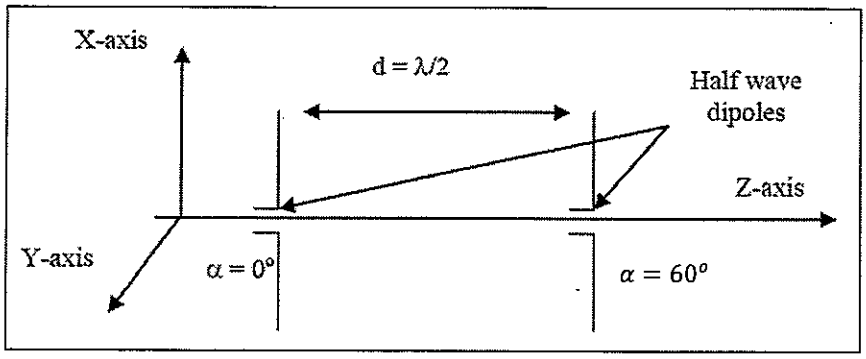

Figure Q2(a)

(i) Determine the array factor for this arrangements.

[6 marks]

(ii) Calculate the pattern maximum and pattern nulls for the E-plane of this array.

[6 marks]

Continued...

(b) A uniform linear array consists of 10 half-wave dipoles with an inter-element separation $d = \frac{\lambda}{4}$ and equal current amplitude. Find the excitation current phase difference α such that the main beam direction is at 60^o ($\phi_{max} = 60^o$).

[4 marks]

(c) Explain the effect of reducing/increasing the antenna array spacing *d*, between each element in the antenna array (with all the other parameters constant) on the radiation pattern.

(i) When *d* equal to $\frac{\lambda}{2}$ or less than $\frac{\lambda}{2}$.

(ii) When *d* is bigger than λ.

[4 marks]

Question 3

(a) Yagi-Uda and log-periodic antennas have similar appearance. First, describe the advantages and disadvantages of Yagi Uda antenna. Secondly, using suitable diagrams, describe the main differences between Yagi-Uda and log-periodic antennas.

[10 marks]

(a) Discuss the differences and similarities between microstrip patch, horn, dipole and helical antennas, in terms of their radiation pattern, gain and polarization.

[10 marks]

Question 4

(a) Explain in brief the structure of ionosphere with the help of a diagram.

[6 marks]

(b) A short wave link broadcasts via the ionospheric E-layer. The critical angle and the virtual height at the midpoint of the path are 60°(with respect to vertical plane) and 80km respectively. Calculate the maximum service range obtained in a single-hop transmission via this layer when the greatest virtual height is 100km. The radius of earth is assumed to be 6400km.

[6 marks]

Continued...

(c) Sky wave communication between two points on earth's surface at a distance of 2500km is to be established using reflection from F1 layer at a virtual height of 200km. The critical frequency is 4 MHz at the reflection point. The effective Earth radius due to refraction, R' is 8500km.

i. Determine the electron density at the reflection point.

ii. Find the maximum usable frequency (MUF) and the optimum working frequency (OWF).

iii. Ignoring collisions, determine the refractive index of ionosphere at 200km virtual height for OWF. Discuss this result.

[8 marks]

Question 5

(a) A tracking patrol car with an antenna on the rooftop of the car approximately 1.5m above the ground is communicating with another patrol car and the nearby station. The station uses a central dispatcher with an antenna at the rooftop of the station with 15m high. Calculate the maximum communication distance:

i. Between the central dispatcher at the station and a patrol car.

ii. Between the two patrol cars.

[6 marks]

(b) Your cell phone transmits at a power level of 500 mW, and an antenna gain of 2 dBi. The cell tower has an antenna gain of 8 dBi, and for LTE, you're transmitting at 700 MHz. How far from the tower could you be while maintaining the capability to communicate? (Assume cellular "dead zone" occurs when the receive power $P_r < -110$dBm)

[4 Marks]

(c) A transmitter with an antenna gain of 40dB radiates a power of 20 watts operating at 8GHz frequency. The receiver uses a similar antenna and is located at a distance of 60km. Determine the received power in watts at the receiveing antenna.

[6 marks]

(d) What is meant by diffraction of radio waves and under what condition does it arise?

[4 marks]

Continued...

Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	3×10^8 m/s
Electron charge	q	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s
Electron rest mass	m	9.11×10^{-31} kg
Effective electron mass	m_e	$0.068m$
Effective hole mass	m_h	$0.56m$

$$P_{rad} = 40\pi^2\left[\frac{L}{\lambda}\right]^2 I_m^2$$

$$AF = a_1 e^{j\alpha_1} + a_2 e^{j(\beta d\cos\theta+\alpha_2)} + a_3 e^{j(2\beta d\cos\theta+\alpha_3)} + \ldots + a_N e^{j((N-1)\beta d\cos\theta+\alpha_N)}$$

$$|AF| = \frac{\sin(\frac{N\psi}{2})}{\sin(\frac{\psi}{2})} \quad \psi = \beta d\cos\theta + \alpha \quad \theta_{\max} = \cos^{-1}\left[-\frac{\lambda}{2\pi d}(\alpha \pm m2\pi)\right]$$

$$P_D = \frac{P_{tx}G_{tx}}{4\pi R_{tx}^2} \qquad h_{inc} = \frac{D_1 D_2}{2KR} \qquad r = \sqrt{\frac{D_1 D_2 \lambda}{D_1 + D_2}}$$

$$E = \frac{\sqrt{30P_t \bullet G_t}}{d} \qquad E_R = 2\frac{E_0}{d}\sin(\frac{2\pi}{\lambda}\bullet\frac{h_t h_r}{d})$$

$$n = \sqrt{\varepsilon_r} = \frac{\sin\theta_i}{\sin\theta_r} = \sqrt{1-\frac{81N}{f^2}} \qquad MUF = f_{cr}Sec\theta_i$$

$$d = 2R\left[(\pi/2-\beta)-\sin^{-1}\left(\frac{R}{R+h}\cos\beta\right)\right] \qquad d_{\max.single\text{-}hop} = 2R\cos^{-1}\left(\frac{R}{R+h_{\max}}\right)$$

$$\sin\theta_i = \frac{\sin\frac{d}{2R'}}{\sqrt{\left(\frac{h}{R'}\right)^2 + \left(1+\frac{h}{R'}\right)\sin^2\frac{d}{4R'}}}$$

End of paper.